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EFFECT OF HOT WATER TREATMENT ON POSTHARVEST DISEASE DEVELOPMENT AND POSTHARVEST QUALITY OF SWEET POTATO (*Ipomoea batatas*)

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ABSTRACT

Postharvest losses is a major constraint for sweet potato (*Ipomea batatas*) production in Malaysia. The loss is very often initiated by pathogen infection during storage. The efficacy of hot water treatment (HWT) in preserving the postharvest quality of sweet potato cv. Gendut was investigated in this study. All tubers were treated with HWT (45°C, 50°C and 55°C), subjected to 10 minute and 20 minute immersion time and incubated for 25 days at room temperature (27°C±2°C). Sweet potatoes treated with 50°C for 10 min immersion period showed the lowest score for disease severity, however, it was only effective in reducing disease development but not for the other postharvest qualities assessed. In this study, the application of HWT at 45°C for 10 min immersion time was able to maintain the other postharvest qualities such as weight loss, firmness, titratable acidity and total soluble solid (TSS) of the treated sweet potatoes. It showed that HWT at the temperatures ranging between 45°C to 50°C at 10 min immersion period had the potential in extending the shelf life of sweet potatoes. It reduced the disease severity as well as preserving the important postharvest qualities of sweet potato.

Key words: Disease severity, weight loss, firmness, total soluble solid and titratable acidity

INTRODUCTION

Malaysia produces approximately 43211 tonnes of sweet potato (*Ipomea batatas*) annually from 2799 hectares of land (Jabatan Pertanian Semenanjung Malaysia, 2016). Sweet potato cv. Gendut is commonly planted and contributes about 76% of the production in Malaysia. Crops are planted from August and September and harvested between November and December (Norrizzah, 2014). However, postharvest losses are quite often the limiting factor of sufficient production of this particular crop. This may be due to several factors such as improper handling during and after harvest, deficiency in curing and storage infrastructure, lack of proper packing and grading, and also inadequate knowledge in global market requirement and opportunities (Siddique, 2005). Some of the cultivars of sweet potatoes such as 'Banting' and 'Kuala Bikam' have a short shelf-life and are not resistant to fungal diseases such as black rot caused by *Ceratocytis fimbriata*, fusarium surface rot caused by *Fusarium* spp. and rhizopus soft rot caused by *Rhizopus stolonifer*. It has been reported that diseases caused by fungi contribute to about 65-70% losses in production (Ahn, 2000).

Most of the postharvest diseases are controlled by the application of fungicides immediately after harvest as a spray or dip application. This has so far led to a lot of consequences that may be harmful to human and environmental health. These adverse consequences have promoted governmental policies restricting the use of fungicides (Tripathy & Dubey, 2004) and have contributed, together with the increase of pathogen resistance, to the development and implementation of strategies for reducing dependence on agrochemicals. In this sense, the use of heat treatment could be considered as an environmental friendly method of postharvest decay control, either alone or in combination with other methods. In addition, the heat treatment has also been shown to have beneficial effects on delaying the parameters related to postharvest fruit ripening and preserving the fruit quality and can also increase storage time.

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Therefore, this study was conducted to determine the effect of hot water treatment (HWT) on postharvest disease development on sweet potato during storage by measuring the optimum temperature and duration of immersion in hot water to slow the deterioration process. Additionally, this study aims to introduce a safer and more cost effective method to control postharvest diseases and preserve the postharvest quality of sweet potato during storage.

MATERIALS AND METHODS

In vivo assay was conducted to examine the effect HWT on the postharvest disease development and postharvest quality of sweet potato cv. Gendut. There were three different temperatures of HWT that have been tested on sweet potatoes and each HWT was subjected to 10 min and 20 min immersion time; T2 (45°C for 10 min), T3 (45°C for 20 min), T4 (50°C for 10 min), T5 (50°C for 20 min), T6 (55°C for 10 min), and T7 (55°C for 20 min). Untreated (control) tubers were immersed in sterile water at room temperature only (T1). All the treated sweet potatoes including control were stored at room temperature (27°C±2°C) for 25 days. Three replicates had been set up for each treatment. The assessment of postharvest quality and postharvest disease development on the treated sweet potato was conducted at every five days interval. The postharvest quality assessment was measured by percentage of weight loss, titratable acidity, firmness, and total soluble solid (TSS) of the treated sweet potatoes (Jiwen *et al.,* 2014; Nur Azlin *et al.,* 2014). The disease severity of symptoms developed on treated sweet potato was recorded and the pathogens were isolated from the infected tissue based on 0-5 scale; 0=no symptom, 1=less than 1% area infected, 2=1-10% area infected, 3=11-20% area infected, 4= 21-50% area infected, and 5=51% or more area infected (Munir *et al.,* 1994). The disease severity index was then calculated using the formula by Hu & Tanaka, (2007). The identification of the pathogens was conducted based on colony morphology and spore characteristics. All the fungal isolates obtained in this study were subjected to pathogenicity test with the control tuber which were inoculated with clean PDA only to complete the Koch's postulate (Anthony *et al.,* 2015). The experiment was conducted in Complete Randomized Design (CRD). All the data obtained were analysed by ANOVA using SPSS version 20. The means, that were different were separated using Tukey test at $p \leq 0.05$.

RESULTS AND DISCUSSION

In vivo assay

Among all treatments applied in *in vivo* assay, sweet potatoes treated with T4 showed the lowest score for disease severity (Figure 1). However, this treatment was only effective in reducing the postharvest decay but not for other postharvest qualities assessed. These results are in line with the study by Erabaduputiya (2005) who used HWT with the same temperature and same immersion time (50°C and 10 min) on infected mango. In an another study, anthracnose and finger rot of 'Latundan' and 'Saba' bananas was also inhibited by HWT at 47-52°C for 10-20 min (Acedo *et al.,* 2001). Hu & Tanaka (2007) reported that immersing sweet potatoes in HWT at 50°C for 8-20 min inhibited sprout growth and had the potential to control decay at a level comparable to the fungicide Dichloron. Control of postharvest diseases is necessary when long transit time is needed for export. Demands for non-chemically treated horticultural crops are increasing worldwide (Erabaduputiya, 2005). However, HWT at temperature over 51°C for a time period ranging between 25 min to 32 min resulted over 45% of rot incidence in avocado (Fallik, 2004). This temperature and duration should be avoided to retain the good quality of stored sweet potatoes.

In the present study, T2 was able to maintain the other postharvest qualities such as weight loss, firmness, titratable acidity and TSS of the treated sweet potatoes (Figure 2A-D). There were significant effects ($p \leq 0.05$) of HWT on the percentage of weight loss of sweet potato (Figure 2A). All treatments were significantly higher in weight loss compared to control except for T2, which significantly displayed lower weight loss (3.2%) compared to other treatments including control. The percentage of weight loss of the sweet potato increased over the storage time. Sweet potatoes undergo weight loss during storage due to water loss through transpiration and loss of dry matter through the physiological change of respiration and infection (Dasai & Wagh, 2001). Increase in the weight loss of the produce was directly proportional to the heat treatment duration. Loss of moisture content may be due to differences in relative humidity between the environment inside the storage area and the atmosphere (Ismail & Wilhitte, 1999). Immersion of sweet potato in hot water at 45°C for 7-12 min can retain the original weight for one to two weeks (Fallik, 2004). Our study also clearly supported that T2 is effective in maintaining the water content in sweet potato. Temperature increase from 37-46°C for 7-10 min can delay the water loss in sweet potato

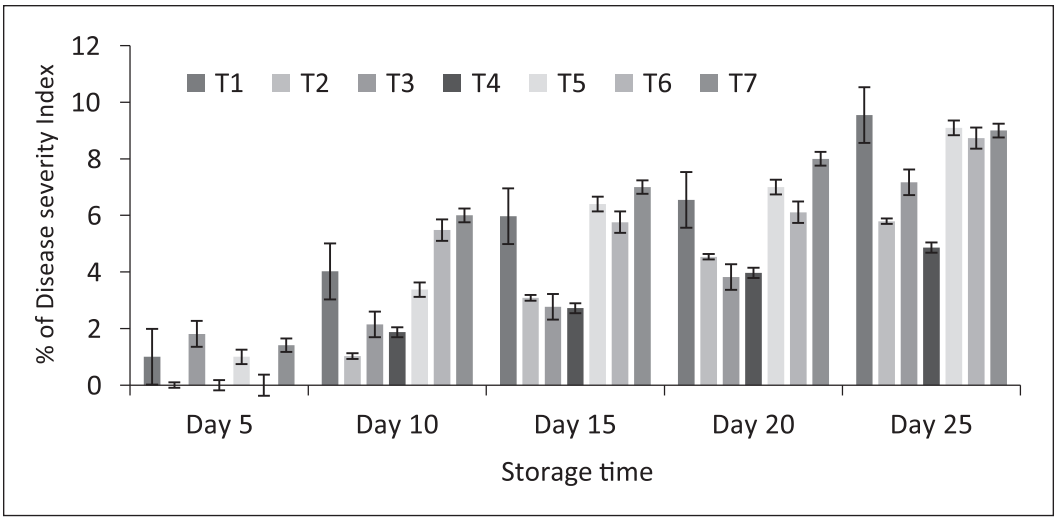

Fig. 1. Percentage of disease severity index of treated sweet potatoes incubated at room temperature for 25 days of storage. T1: Control (sterile water at room temperature), T2: 45°C (10 min), T3:45°C (20 min), T4:50°C (10 min), T5:50°C (20 min), T6:55°C (10 min), and T7: 55°C (20 min).

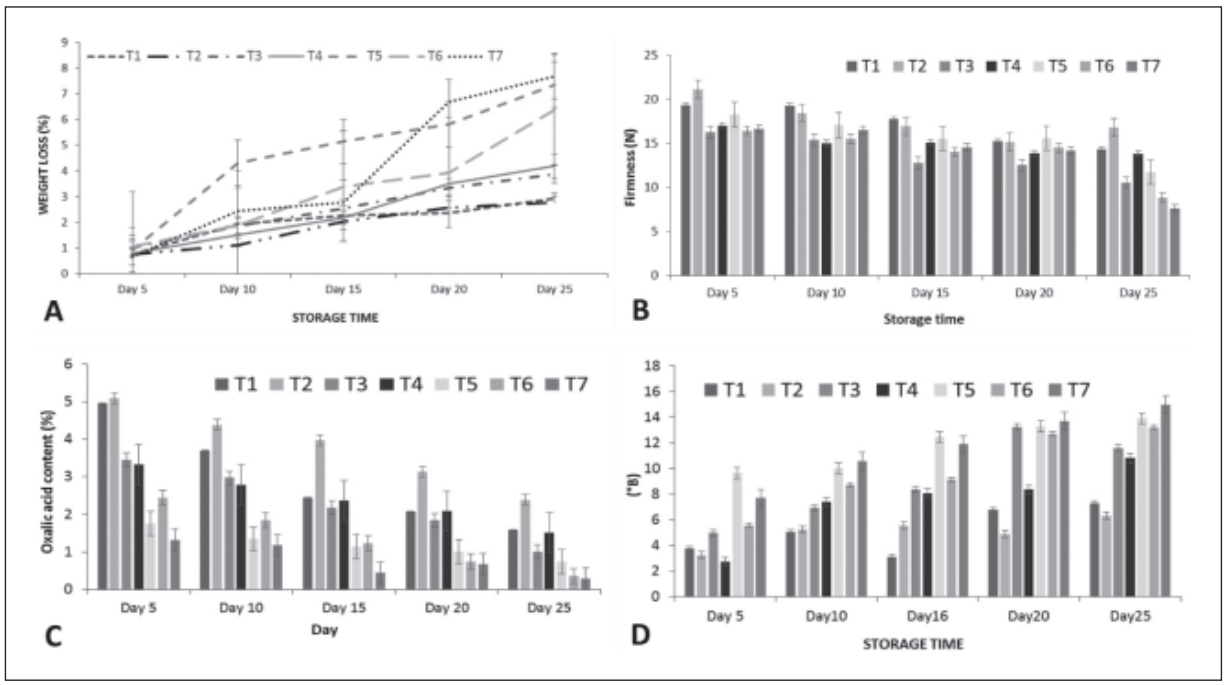

Fig. 2. Effect of different treatments, T1: Control (sterile water at room temperature), T2: 45°C (10 min), T3:45°C (20 min), T4:50°C (10 min), T5:50°C (20 min), T6:55°C (10 min), and T7: 55°C (20 min) on A) percentage of weight loss; B) firmness; C) titratable acidity; and D) total soluble solid of the treated sweet potatoes incubated at room temperature (27°C±2°C) for 25 days.

during storage at 27°C for one to three weeks (Kubota, 2006). Meanwhile, T7 treatment showed higher water loss due to exposure at high temperature for longer duration. These results confirmed the findings of Park & Jung (1996) and Schirra *et al*. (2000) who reported rapid weight loss in sweet potatoes exposed to higher temperature and for longer duration of heat treatment. Higher temperature (>52°C) during heat treatment has been reported to cause plant tissue damage and shrinking, resulting in increased weight loss (Lurie & Mitcham, 2007). In this case, exposing tubers to a temperature of 55°C for 20 min may have been too extreme for the sweet potatoes. However, these results differed from the study by Hu & Tanaka (2007), who applied the same temperature as T7

(55°C 20 min) in sweet patato cv. 'Kanoya' but found lesser weight loss in hot water treated samples compared to control. These different results obtained may be due to the difference in cultivar and storage temperatures, which has also been documented by Lurie & Mitcham (2007).

There was a significant effect ($p \leq 0.05$) of HWT on the firmness of treated sweet potato (Figure 2B). Application of T2 showed significant results in maintaining the firmness and improving textural structure of sweet potatoes compared to the other treatments. Meanwhile, T7 showed the lowest firmness after 25 days, which indicated that higher temperature and longer immersion time could possibly accelerate the degradation of cell wall of sweet potato. Heat treatment may lead to undesirable quality change in fresh produce such as visual appearance and firmness (Rico *et al.,* 2007). Changes in sweet potato firmness are also considered as important indicators that sweet potato undergoes water loss during storage. In general, as temperature and storage time increase, firmness decreases. Heating whole tubers at 45°C 10 min improved the texture of tubers as compared to control tubers but this improvement depends upon cultivar (Agu, 2014). In this study, the firmness of the sweet potato treated with T2 can retain the firmness during storage better than the control sweet potato. A possible explanation is that such heating activates pectin methylesterase, which then demethylates pectic substances that allow cross-linking of the freed caboxyl groups by internal calcium ions that can improve the firmness during storage (Erabaduputiya, 2005). Produces treated with HWT for 15 min at 43.5°C followed by storage for 7-15 days at 27°C led the fruit to become slightly tougher and firmer compared to untreated fruit (Sairi, 2010). This result was supported by Shao *et al*. (2007) who reported that temperature (≥38°C) can inhibit the synthesis of cell wall hydrolytic enzymes and delay the solubization of pectins and hemicelluloses.

Figure 2C indicates that organic acids decreased with increase in storage time. There was a significant effect ($p \leq 0.05$) of HWT on organic acid content of treated sweet potatoes after 25 days of storage. T2 showed the higher percentage of organic acid compared to other treatments, thus could possibly be an effective treatment in slowing down the respiration and senescence in sweet potato. Oxalic acid is the main organic acid in sweet potato's flesh, accounting about 53.7% of total acids. The HWT significantly accelerated the decrease in organic acid content in sweet potato. Several studies also showed that organic acid is easily degraded upon application of heat treatment (Rawson *et al.,* 2011). T2 treatment was significantly effective in retaining the titrable acidity value in sweet potato during storage up to day 15 with less water loss, and showed no changes in organic acid content and soluble solid content. However, heat treatment may affect the visual and eating quality of sweet potato when the temperature exceeds certain threshold or exposure duration.

There was a significant effect ($p \leq 0.05$) of HWT on TSS value of treated sweet potatoes after 25 days storage (Figure 2D). T2 treatment showed lower TSS values compared to T1 (control) after 25 days of storage time. The total soluble solid (TSS) in sweet potato increased with increasing the storage duration up to 25 days but declined after 30 days (Park & Jung, 1996). These results were supported by previous studies which described that HWT at 45°C for 10 min significantly decreased the total soluble solid content and increased the organic content in sweet potato (Wang *et al.,* 2012) and mango (Jacobi *et al.,* 2000). However, these results was in contrast with Kim *et al*. (2009), who showed that application of hot water at 46.1°C for 10 min had no effect on soluble content of 'Toka-Toka Gold' sweet potato stored at 15°C. Djioua *et al*. (2009) indicated that hot water treatment at 45°C for 10 min induced a slight decrease until 6th day of storage, but after 9th day of storage the final TSS value was higher than at the beginning of the experiment on 'Beniotome' sweet potato. These different results obtained may be due to different cultivars and storage temperatures (Hu, 2004) used in the respective studies.

Pathogenicity test

A total of 10 fungal isolates were obtained from this study. Nevertheless, they were all identified as *Rhizopus stolonifer* and *Fusarium oxysporum*. The pathogenicity test showed no significant difference ($p \geq 0.05$) between *R. stolonifer* and *F. oxysporum* as shown in Figure 3. The results of pathogenicity test indicated that these fungi induced different level of decay with *R. stolonifer* causing slightly more severe disease symptoms. In South Western Nigeria, *R. stolonifer* was reported to be one of the most virulent fungi associated with storage rots of tuber crops (Nahunnaro, 2008). After 18 days of inoculation with *R. stolonifer* and *F. oxysporum* tubers showed symptoms similar to the reported symptoms. The color of infected sweet potato turned brownish and blackish with the development of white mycelium and the skin became softer for *R. stolonifer*, while for *F. oxysporum* the symptoms appeared as pale brown circular lesions and formed a cavity with white mold at the lesion area. Koch's postulate was completed by the re-isolation of the pathogen from the inoculated sweet potatoes.

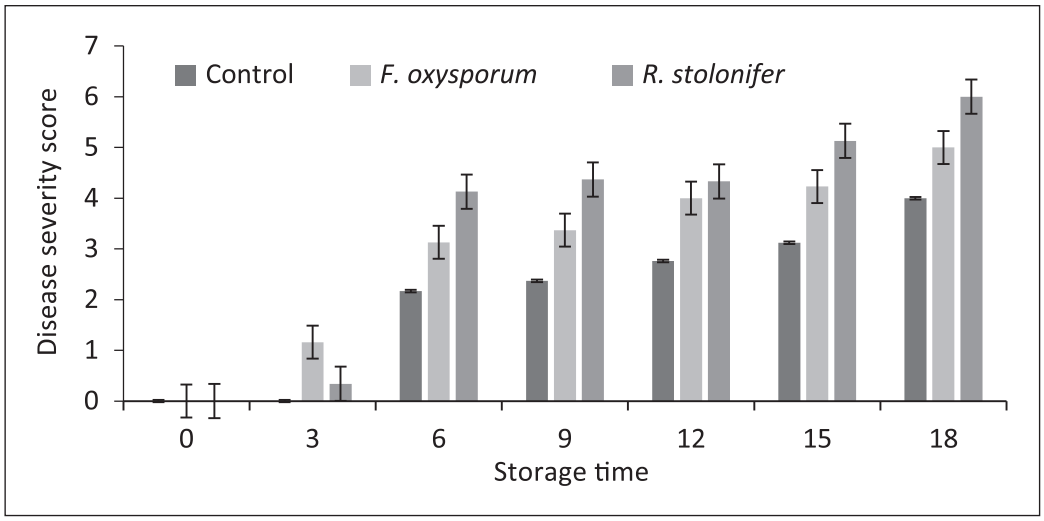

Fig. 3. Disease severity score of sweet potatoes inoculated with *Fusarium oxysporum* and *Rhizopus stolonifer* after two weeks incubation at room temperature (27°C±2°C).

CONCLUSION

In the present study, sweet potato cv. Gendut treated with T2 was able to maintain the firmness, organic acid and total soluble solid content. This treatment also contributed in reducing the percentage of weight loss in sweet potato. Meanwhile, T4 treatment demonstrated lower disease severity in sweet potato. It showed that HWT at the temperatures ranging between 45°C to 50°C and immersion time for 10 min has the potential in prolonging the shelf life of sweet potato by reducing the disease incidence and help in improving the postharvest quality of sweet potato.

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